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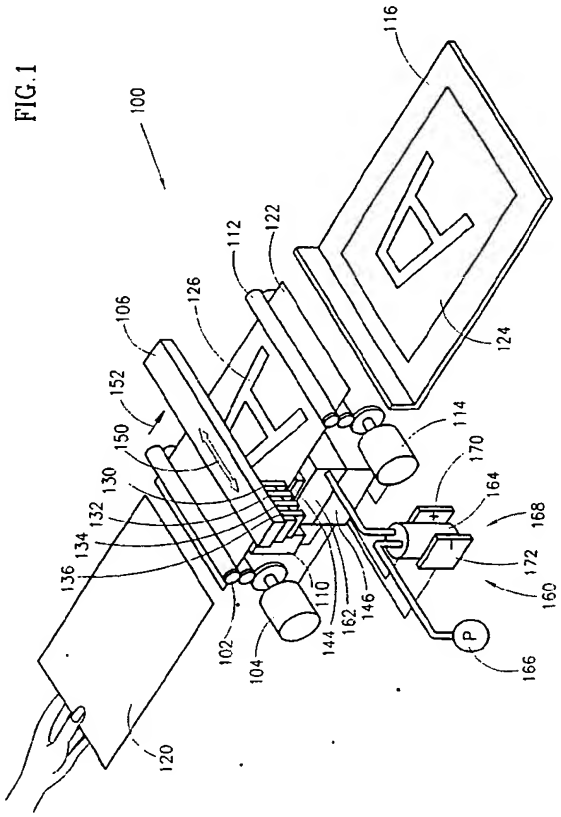
## (54) Apparatus and method for printing

(57) A printing system (100) is provided which includes a printing head (106) for applying at least one ink to a printing substrate (120,122,124) and at least one radio frequency (RF) drying unit (140) for discharging RF energy, thereby drying the ink on the printing substrate. A printing system is also provided which includes a printing (206) and drying (238) head for applying at least one ink to a printing substrate and for subsequently drying it. The printing system further includes means for moving the printing head with respect to the printing substrate.

FIG.1

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## Description

### FIELD OF THE INVENTION

The present invention relates to printing systems generally and more particularly to printing systems which employ relatively slow drying inks, such as water based inks.

### BACKGROUND OF THE INVENTION

Printing systems which employ relatively slow drying inks for printing, such as printing systems which employ water based inks, are well known in the art. Unfortunately, slow drying inks dry slowly on printing substrates in general and on impervious printing substrates, such as vinyl, in particular. Another drawback of slow drying inks is color bleeding, i.e. the mixing on the printing substrate, of one color with a formerly applied color that has not completely dried.

Therefore, prior art printing systems which employ water based inks are limited in their printing rates and printing quality.

However, such printing systems are more environmentally friendly and do not contain volatile organic carbon components which may be hazardous.

### SUMMARY OF THE INVENTION

It is an object of the present invention to provide an improved printing system.

According to one aspect of the present invention, there is provided a printing system which employs radio frequency (RF) radiation for drying the applied ink after it has been applied to the printing substrate, preferably immediately thereafter.

According to one aspect of the present invention, there is provided a printing system which employs RF radiation for "on-the-fly" drying of the ink (i.e. as the ink is applied to the printing substrate.)

According to a further aspect of the present invention, there is provided a printing system which employs RF radiation for drying ink waste residues generated during the operation of the printing system.

There is thus provided, in accordance with a preferred embodiment of the present invention, a printing system which includes a printing head for applying at least one ink to a printing substrate and at least one radio frequency (RF) drying unit for discharging RF energy, thereby drying the at least one ink on the printing substrate.

There is also provided, in accordance with a preferred embodiment of the present invention, a printing system which includes a printing and drying head for applying at least one ink to a printing substrate and for subsequently drying it and means for moving the printing head with respect to the printing substrate.

Further, according to a preferred embodiment of the present invention, the printing and drying head includes at least one printing element for applying one of the at least one ink on the printing substrate and at least one RF drying unit for discharging RF energy, thereby drying one of the at least one ink.

Still further, according to a preferred embodiment of the present invention the at least one RF unit includes an RF generator for producing RF energy and at least one electrode for discharging the RF energy in the vicinity of the printing substrate.

According to one preferred embodiment of the present invention, the at least one electrode includes a positive and a negative electrode located on the same side of the printing substrate.

Alternatively, the at least one electrode includes a positive and a negative electrode located on opposite sides of the printing substrate.

Additionally, according to a preferred embodiment of the present invention the printing system includes an ink waste disposal system which includes a collection unit for collecting the ink residues and an RF waste ink drying unit for discharging RF energy, thereby to vaporize the ink so as to produce a substantially solid ink residue for disposal.

Further, according to a preferred embodiment of the present invention, the ink waste drying RF unit includes an RF generator for producing RF energy and at least one electrode for discharging the RF energy towards the collection unit.

In accordance with a preferred embodiment of the present invention, the same RF generator generates RF energy for the at least one electrode of the RF drying unit and for the at least one electrode of the RF waste ink drying unit.

There is also provided, in accordance with a preferred embodiment of the present invention, a printing system which includes means for applying ink on a printing substrate and an ink waste disposal system which includes a collection vessel for collecting the ink residues and an RF unit for generating RF energy, thereby to vaporize the ink so as to produce a substantially solid ink residue for disposal.

According to a preferred embodiment of the present invention, the at least one ink is a water based ink.

There is also provided, in accordance with a preferred embodiment of the present invention a printing method which includes the steps of:

a. applying at least one ink to a printing substrate; and

b. discharging RF energy, thereby drying the at least one ink on the printing substrate.

There is also provided, according to a preferred embodiment of the present invention a printing method which includes the steps of:

a. applying at least one ink to a portion of a printing

substrate;

b. moving the printing head with respect to the printing substrate; and

c. discharging RF energy, thereby drying the ink applied on the portion of the printing substrate.

Further, according to one preferred embodiment of the present invention the printing method includes the steps of:

a. collecting into a collection unit ink residues; and

b. discharging RF energy towards the collection unit, thereby vaporizing said ink residues, thereby obtaining a substantially solid ink residue for disposal.

Additionally, there is provided, according to a preferred embodiment of the present invention, a method for collecting ink residues of a printing system which includes the steps of:

a. collecting into a collection unit said ink residues; and

b. discharging RF energy towards said collection unit, thereby to vaporize said ink so as to produce a substantially solid ink residue for disposal.

Finally, according to a preferred embodiment of the present invention the at least one ink is a water based ink.

## BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood and appreciated more fully from the following detailed description taken in conjunction with the appended drawings in which:

Fig. 1 is a schematic isometric illustration of a printing system, constructed and operative according to a preferred embodiment of the present invention;

Figs. 2A and 2B are schematic cross section illustrations of one color printing unit of the printing head of the printing system of Fig. 1, constructed and operative according to two preferred embodiments of the present invention;

Figs. 3A - 3C are schematic illustration of the printing head of the printing system of Fig. 1 in three printing positions;

Fig. 4 is a schematic isometric illustration of a printing system, constructed and operative according to another preferred embodiment of the present invention; and

Fig. 5 is a schematic cross section illustration of the printing head of the printing system of Fig. 4.

## DETAILED DESCRIPTION OF THE PRESENT INVENTION

Reference is now made to Figs. 1 - 3C which illustrate a printing system, referenced generally **100**, constructed and operative in accordance with a preferred embodiment of the present invention. Fig. 1 is a schematic isometric illustration of the printing system **100**, Fig. 2A and 2B are schematic cross section illustrations of one color printing unit of the printing head of the printing system **100**, according to two alternative embodiments of the present invention and Figs. 3A -3C are schematic illustration of the printing head of the printing system **100** in three printing positions. Similar elements are referenced in Figs. 1 - 3C by similar reference numerals.

The printing system **100**, may be any printing system, such as an ink-jet printing system. An example of an ink-jet printing system is the SCITEX OUTBOARD printer which is a large format continuous ink-jet printer used, for example, for billboard printing and which is commercially available from Scitex Corporation Ltd. of Herzlia, Israel.

The printing system **100** is a printing system which employs water based inks and includes an "on-the-fly" drying system for drying the inks applied to the printing substrate during printing. The printing system **100** selectively dries the inks applied to the printed substrate.

The printing system **100** preferably comprises any feed-in mechanism, such as rollers **102** operated by a motor **104**, for feeding substrates to be printed into a printing position, a printing head **106** for printing an image on a printing substrate with a water based ink and for drying it thereafter, and a Central Processing Unit (CPU) **110** for controlling the operation of the printing system **100**.

The system **100** also preferably comprises a feed-out mechanism, such as rollers **112** operated by a motor **114**, and a collector **116** for collecting the printed substrates after printing.

For exemplary purposes only, and as a non-limiting embodiment, the printing system **100** will be described with respect to sheets of paper such as the sheet illustrated in three different positions indicated by reference numerals **120**, **122** and **124**. Reference numeral **120** indicates the printed substrate before it is fed into the printing system **100**, reference numeral **122** indicates the printed sheet in a printing position and reference numeral **124** indicates the sheet in the collection system **116** after it has been printed.

It will be appreciated that the printing system **100** may be fed with any suitable substrate to be printed, such as paper or plastic, in any suitable form, such as a continuous roll of paper, and in any format.

The printing head **106** preferably includes four print-

ing units **130**, **132**, **134** and **136**, each of which prints one of the four process colors Cyan, Magenta, Yellow and Black (CMYK) on the printed sheet and subsequently dries it "on-the-fly".

As best seen from Figs. 2A and 2B, which for exemplary purposes only refer to the printing unit **130**, each printing unit preferably includes a printing element **138** and an RF drying element, generally referenced **140**. As described in more detail hereinbelow, each one of the printing units **130**, **132**, **134** and **136** operates to print and to subsequently dry, "on-the-fly", the ink printed on the sheet 122.

Preferably, each one of the RF drying elements comprises a positive electrode and a negative electrode, referenced **142** and **144**, respectively. Each one of the drying units are connected in parallel to an RF generator **146**, which generates RF radiation and any suitable controller, such as the resistor **148**, for controlling the RF output level.

According to one preferred embodiment of the present invention, as illustrated in Fig. 2A, the positive electrode **142** is on one side of the printing sheet **122** whereas the negative electrode **144** is on its other side. Alternatively, as illustrated in Fig. 2B, both the negative electrode **142** and the positive electrode **144** are on the same side of the printing sheet **122**, which is the side of the printing element **138**.

As best seen in Figs. 3A - 3C, the image **126** is printed on the printing substrate **122** in a step wise fashion. During printing, while the printing elements discharge water based ink on the printing sheet **122** to form portions of the image **126**, each one of the RF drying elements **140**, outputs a suitable level of RF output to dry ink previously discharged by its corresponding printing unit. It will be appreciated that as best seen in Figs. 3A - 3C, that each RF drying unit **140** is behind the printing element of one of the printing units **130**, **132**, **134** and **136**.

In the illustrated embodiment, the printing head **106** moves in one direction indicated by arrow **150**, for printing a strip across the printed sheet **122** and after each strip is being printed, the sheet **122** moves one step forward in a generally perpendicular direction **152** to the direction **150** to provide the next strip of the sheet **122** for printing. Figs. 3A, 3B and 3C illustrate the printing head **106** before, during and after printing one strip, respectively.

Preferably, each one of the printing steps of the printing head **106** corresponds to the size of the printing elements **138**. Referring again for exemplary purposes to the printing unit **130**, the printing element **138** discharges cyan ink on the first portion of the strip currently being printed which includes the image. Then, the printing unit moves one step, such that the RF element **140** is above the area covered in the previous step by the printing element **138**. Then, the printing element **138** discharges ink on a second portion of the strip while the RF element **140** dries the ink previously discharged by the printing element **138**. The printing elements and RF drying elements of the printing units **132**, **134** and **136** operates in a similar fashion in sequence after the printing unit **130**.

Since it is environmentally advantageous to dispose ink residues not in the liquid state but in the solid state, the printing system **100** preferably also include a RF waste ink drying system **160** (Fig. 1). The system **160** preferably includes a collection system **162** for collecting ink residues in a collection vessel **164** and a pump **166** for collecting the ink's vapors, such as water vapor resulting from the ink vaporization process. The ink residues are produced during cleaning and maintenance of the printing system **100**.

It is a particular feature of the present invention that the system **160** also includes a RF drying element **168**, which includes positive and negative electrodes, referenced **170** and **172**, respectively, for improving the ink residue drying process in the collection vessel **164**. The RF drying element **168** operates similarly to the drying elements **140** of the printing units. Preferably, but not necessarily, the RF generator **146** also provides RF radiation in the desired level to the RF drying element **168**.

Reference is now made to Figs. 4 - 5 which illustrate a printing system, similar to the printing system **100**, but which employs a different printing head and a different RF drying system associated therewith. Similar reference numerals are used to indicate elements in Figs. 4 and 5 which are similar to those in Figs. 1 - 3C.

In the illustrated embodiment, printing and drying are sequential and not simultaneous as described with respect to the embodiments of Figs. 1 - 3C.

The printing head **206** of the system **200** illustrated in Figs. 4 and 5, generally referenced **200**, preferably includes four printing units **230**, **232**, **234** and **236**, each of which preferably prints one of the four process colors CMYK and an RF drying unit **238** which includes four RF drying units **240**, **242**, **244** and **246** (Fig. 5), each of which includes a positive and a negative electrode. Preferably, each one of the RF drying units outputs RF radiation which is suitable for drying a corresponding ink. For example, in the illustrated embodiment, the RF drying unit **240** operates to dry ink discharged by the printing unit **230** which discharges Cyan ink.

As best seen from Fig. 5, each pair of corresponding printing unit and drying unit, such as the printing unit **232** and the drying unit **242** are located generally in the same position, each on one side of the printing sheet **122**. Preferably, the length of the RF units **240**, **242**, **244** and **246** is generally similar to the width of the printing sheet **122**.

During printing, the four printing units **230**, **232**, **234** and **236** discharge CMYK inks simultaneously to cover a portion of a strip of the printing sheet **122**. Preferably, the printing units **230**, **232**, **234** and **236** operate in a step wise fashion by moving along the direction indicated by arrow **150**. Once a strip is printed, the RF generator **146** outputs RF radiation which is modulated to the

desired level by each one of the suitable controllers, such as the resistors **250**, **252**, **254** and **256**, each of which controls the RF output level in accordance with the properties of the corresponding ink to be dried.

Then, the printing sheet **122** moves one step in the direction indicated by the arrow **152** and another strip is printed.

It will be appreciated that, since each point on the printing sheet **122** is printed typically by four printing colors, the steps of the sheet **122** in the direction **152** are such that a new strip includes a portion of the previous strip which has not been yet printed with all the desired printing inks.

It will be appreciated that the preferred embodiments described hereinabove are described by way of example only and that numerous modifications thereto, all of which fall within the scope of the present invention, exist. For example, the present invention is not limited to CMYK inks and any additional ink or a substitute for one of the CMYK colors may be employed.

It will be appreciated by persons skilled in the art that the present invention is not limited to what has been particularly shown and described hereinabove. Rather, the scope of the present invention is defined only by the claims that follow:

## Claims

1. A printing system comprising:

   a. a printing head for applying at least one ink to a printing substrate; and
   b. at least one radio frequency (RF) drying unit for discharging RF energy, thereby drying said at least one ink on said printing substrate.

2. A printing system comprising:

   a. a printing and drying head for applying at least one ink to a printing substrate and for subsequently drying it; and
   b. means for moving said printing head with respect to said printing substrate.

3. A printing system according to claim 2 and wherein said printing and drying head comprises:

   a. at least one printing element for applying one of said at least one ink on said printing substrate; and
   b. at least one RF drying unit for discharging RF energy, thereby drying one of said at least one ink.

4. A printing system according to either of claims 1 or 3 wherein said at least one RF unit comprises:

   a. an RF generator for producing RF energy;
   b. at least one electrode for discharging said RF energy in the vicinity of said printing substrate.

5. A printing system according to claim 4 wherein said at least one electrode comprises a positive and a negative electrode located on the same side of said printing substrate.

6. A printing system according to claim 4 wherein said at least one electrode comprises a positive and a negative electrode located on opposite sides of said printing substrate.

7. A printing system according to any of the previous claims and also comprising an ink waste disposal system, said waste disposal system comprising:

   a. a collection unit for collecting said ink residues; and
   b. an RF waste ink drying unit for discharging RF energy, thereby to vaporize said ink so as to produce a substantially solid ink residue for disposal.

8. A printing system according to claim 7 wherein said ink waste drying RF unit comprises:

   a. an RF generator for producing RF energy;
   b. at least one electrode for discharging said RF energy towards said collection unit.

9. A printing system according to claim 8 wherein the same RF generator generates RF energy for said at least one electrode of said RF drying unit and for said at least one electrode of said RF waste ink drying unit.

10. A printing system comprising:

    a. means for applying ink on a printing substrate; and
    b. an ink waste disposal system, said waste disposal system comprising:

       i. a collection vessel for collecting said ink residues; and
       ii. an RF unit for generating RF energy, thereby to vaporize said ink so as to produce a substantially solid ink residue for disposal.

11. A printing system according to any of the previous claims wherein said at least one ink is a water based ink.

12. A printing method comprising the steps of:

a. applying at least one ink to a printing substrate; and
b. discharging RF energy, thereby drying said at least one ink on said printing substrate.

**13.** A printing method comprising the steps of:

a. applying at least one ink to a portion of a printing substrate;
b. moving said printing head with respect to said printing substrate; and
c. discharging RF energy, thereby drying the ink applied on said portion of said printing substrate.

**14.** A printing method according to eiother of claims 12 or 13 and also comprising the steps of:

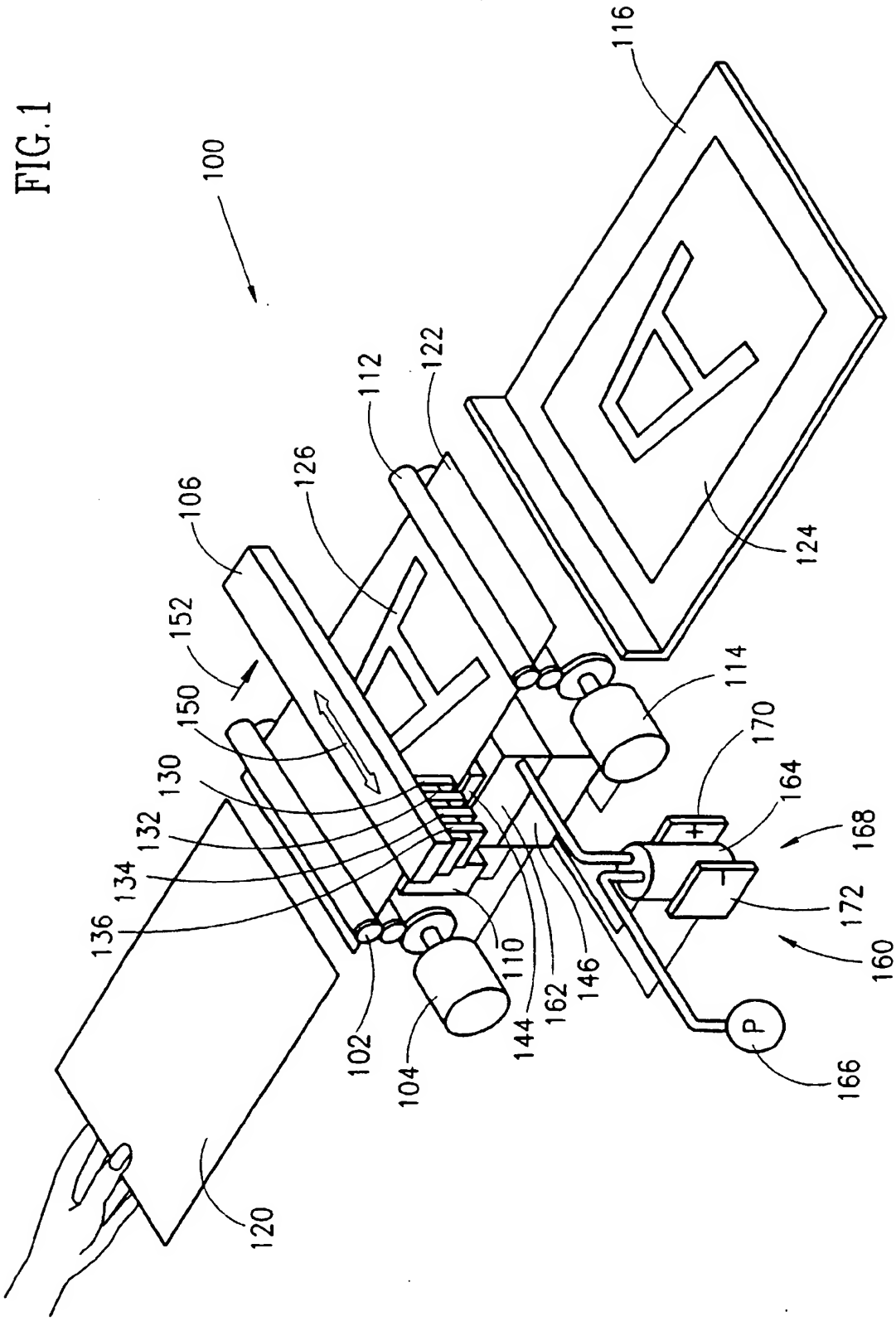
a. collecting into a collection unit ink residues; and
b. discharging RF energy towards said collection unit, thereby vaporizing said ink residues, thereby obtaining a substantially solid ink residue for disposal.

**15.** A method for disposing ink residues of a printing system comprising the steps of:

a. collecting into a collection unit said ink residues; and
b. discharging RF energy towards said collection unit, thereby to vaporize said ink so as to produce a substantially solid ink residue for disposal.

**16.** A printing method according to any of claims 12 - 15 wherein said at least one ink is a water based ink.

FIG.1



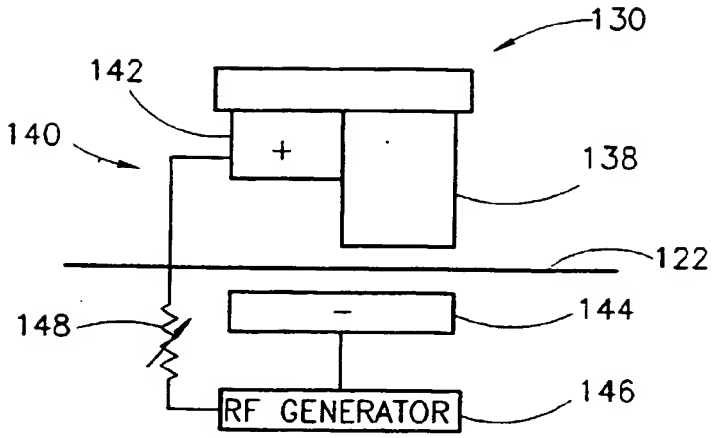



FIG.2A

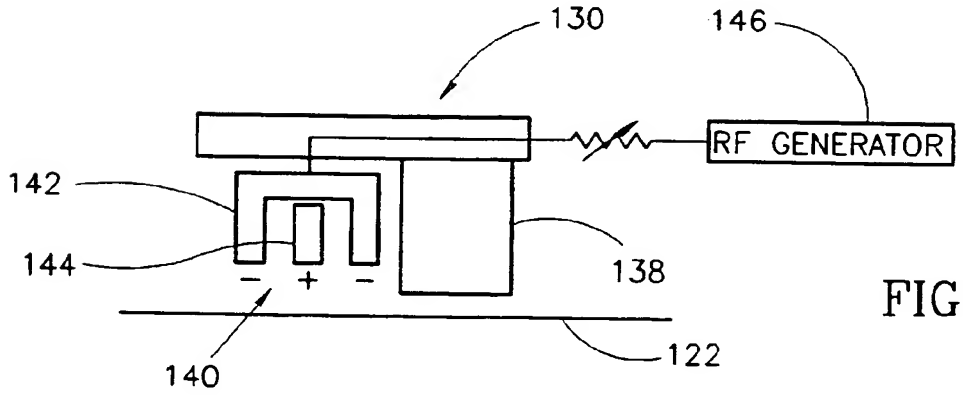



FIG.2B

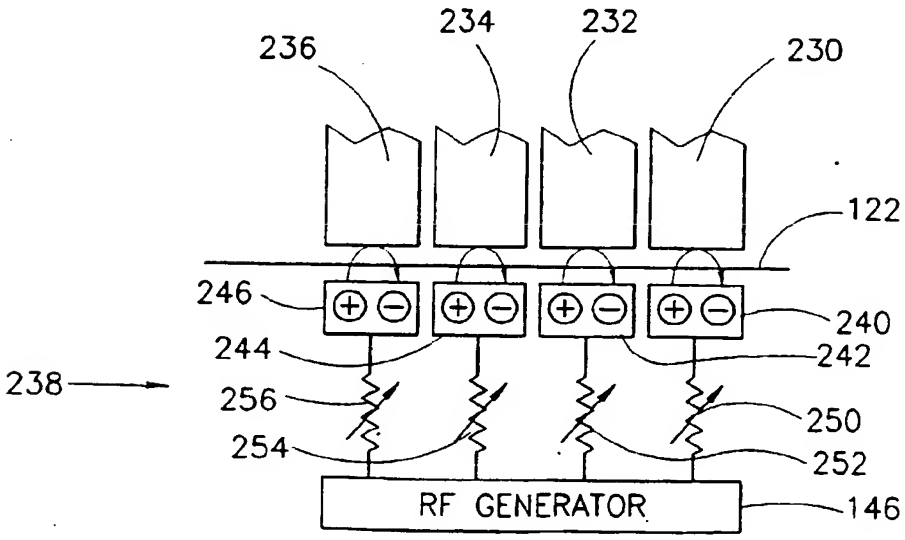



FIG.5

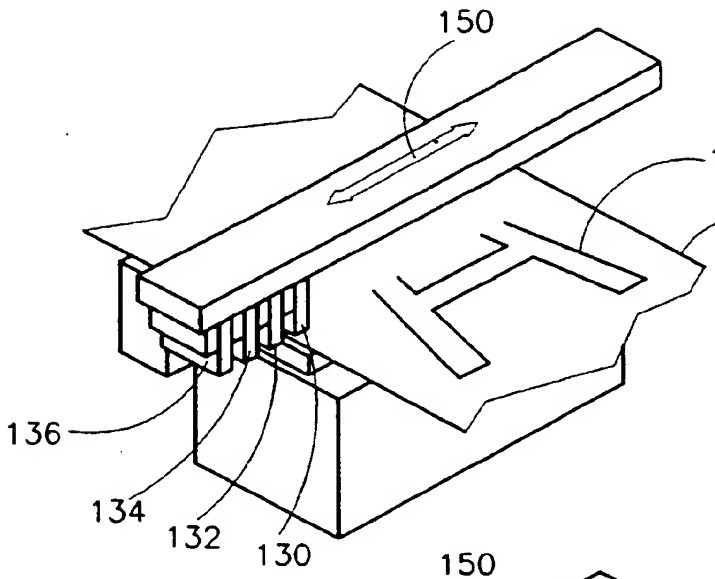



FIG.3A

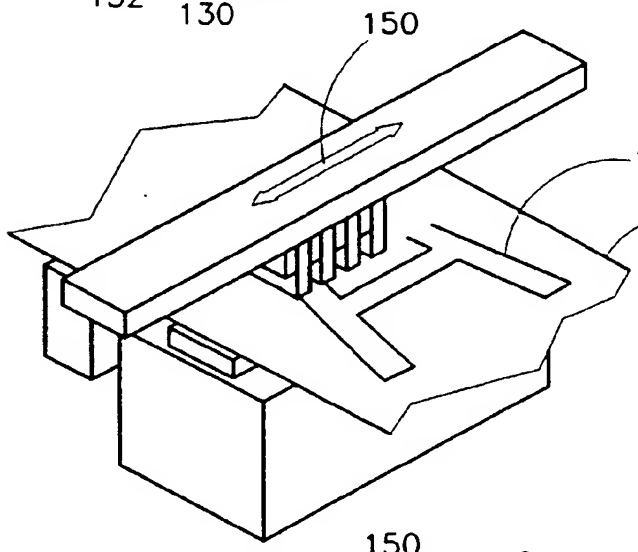



FIG.3B

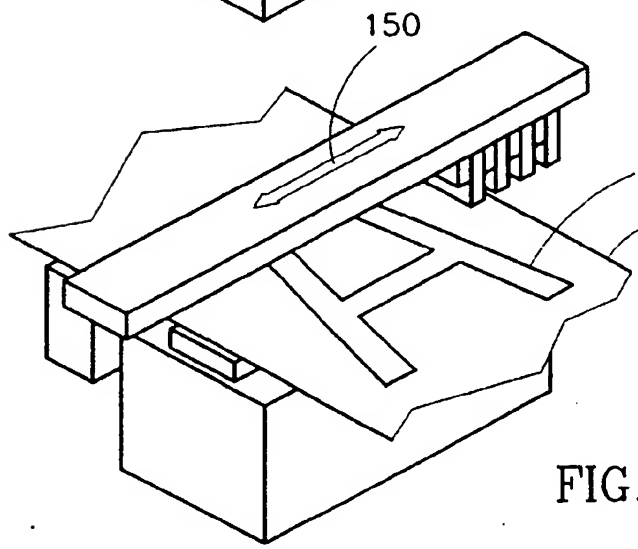
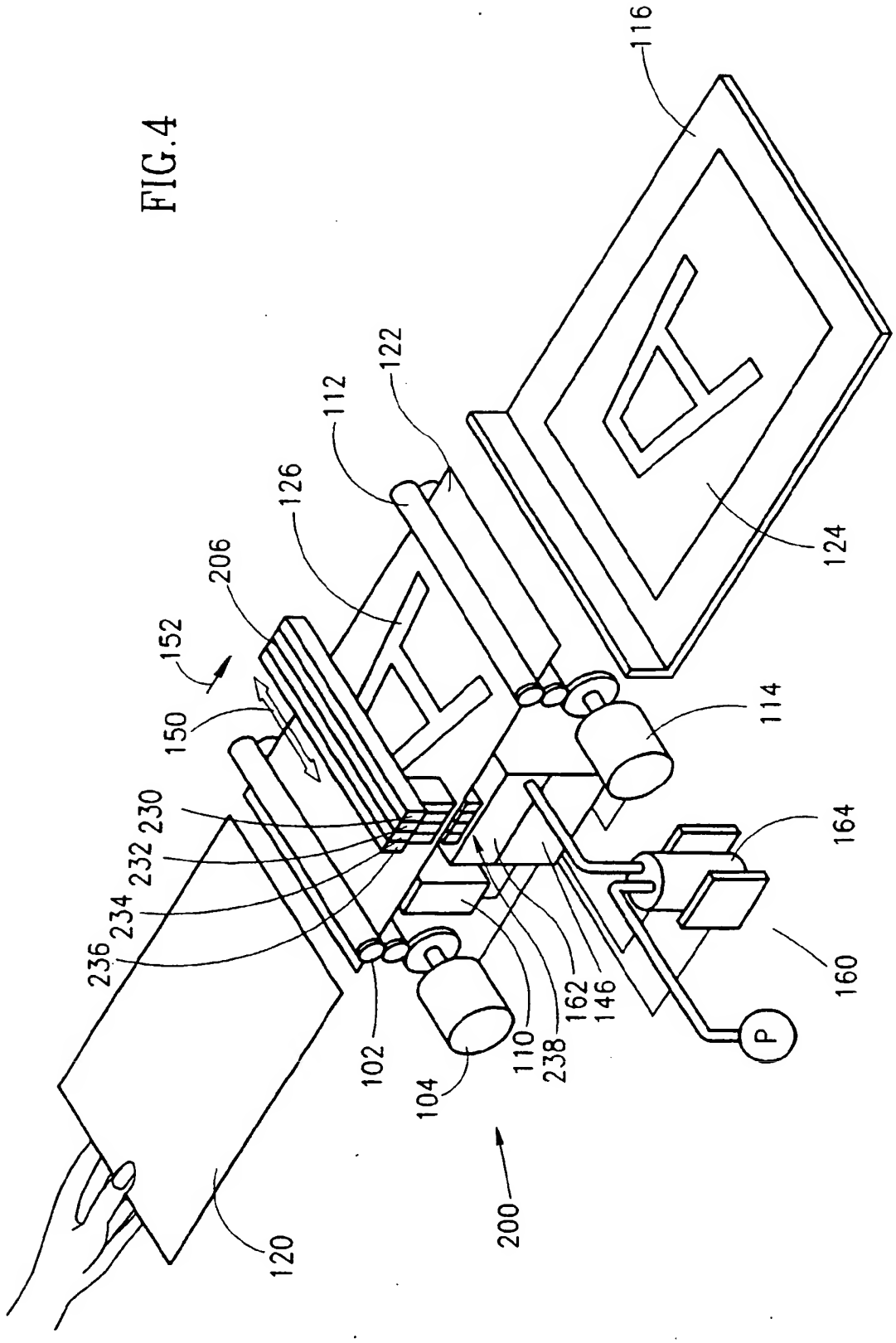



FIG.3C

FIG.4



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# EUROPEAN SEARCH REPORT

Application Number
EP 96 30 2465

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int.Cl.6) |
|---|---|---|---|
| X<br>X | US-A-4 566 014 (S.C. PARANJPE)<br>* column 3, line 36 - line 58 *<br>* figure 1 * | 1,11<br>12,16 | B41J2/17 |
| A | US-A-5 212 498 (M. SUGIMORI)<br>* the whole document * | 2 | |
| A | US-A-4 638 571 (W.A. COOK)<br>* the whole document * | 4-6 | |
| Y | PATENT ABSTRACTS OF JAPAN<br>vol. 95, no. 002<br>& JP-A-07 032607 (CANON INC), 3 February 1995,<br>* abstract * | 7,10,15 | |
| Y | US-A-5 174 864 (T. ARBIZZANI)<br>* the whole document * | 7,10,15 | |

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

B41J
B41F

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| THE HAGUE | 21 June 1996 | Van den Meerschaut,G |

CATEGORY OF CITED DOCUMENTS

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